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Management Report

RESOURCES FOR HARDWARE COMMISSIONING

PART 1: THE COMMISSIONING OF THE SUPERCONDUCTING MAGNET CIRCUITS AND THE ASSOCIATED TECHNICAL SYSTEMS

Abstract

It is expected that the hardware commissioning will be dominated by the commissioning of the very complex powering system for superconducting magnets and its associated infrastructure. Time and investment for additional personnel will be mainly spent for this activity.

This document presents **the resources identified for a commissioning scenario restricted by a number of assumptions**: in particular, the parallel commissioning of two sectors around an even point -**not more and not less**- and the staggered commissioning of an additional set of two sectors where the cool down follows the powering tests of the first set (see page 4).

However from the data presented in this document, it is possible to derive the resources needed for a different scenario when some of the restrictions are lifted or relaxed.

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History of Changes

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1.0	2004-11-15	18	Source for Technical Engineer and Engineer for Cryo Instrumentation was updated to include also National Institutes Head count was corrected First approved version

Table of Contents

1. INTRODUCTION

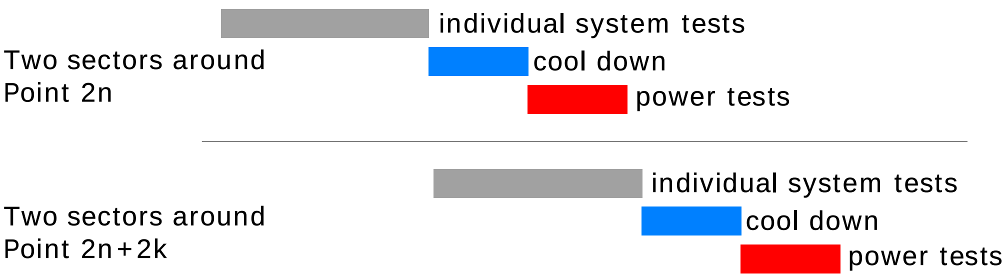
It is expected that the hardware commissioning will be dominated by the commissioning of the very complex powering system for superconducting magnets and its associated infrastructure [1-8]. Time and investment for additional personnel will be mainly spent for this activity. A first estimate of the personnel required for the hardware commissioning was completed in March 2004 following a recommendation from the MAC in December last year.

This first version showed a need of about 100 persons deployed in the field with the assumption of a five day week two-shift parallel commissioning of two sectors situated around an even point.

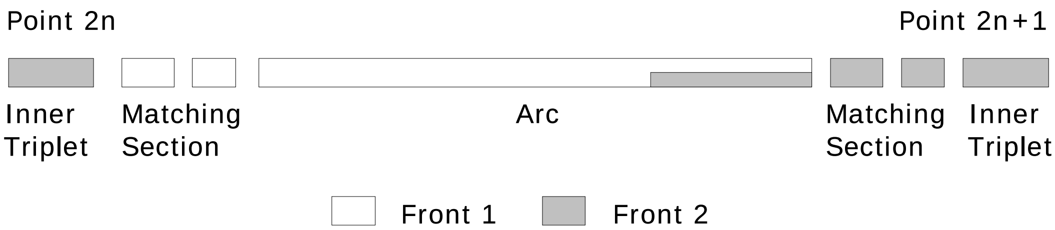
A second iteration took place in the Departments at the initiative of the Department Leaders with the objective of finding the additional resources required for the accelerated installation and commissioning schedule. During this exercise a more precise picture emerged: it better detailed how, when the different tests would be carried-out and what type of resources would be deployed. This document is a consolidation of the second iteration.

2. BASIC ASSUMPTIONS

1. Parallel commissioning of two sectors (not more, not less) around an even point. Resources for the same type of activity have been planned only for two sectors. **This does not exclude the possibility of a staggered commissioning of another set of two sectors as long as the same activity is not taking place on more than two sectors**. This implies that the teams involved in the Individual System Tests (IST) at warm should not be redeployed on activities taking place during the powering tests.



2. Five-day working weeks
3. Two shifts during the powering tests
4. Two commissioning fronts on each sector during the powering tests: one front attacks the arc and the matching section on the even side and the other the arc, the matching section on the odd side and the inner triplet(s)



5. An operation team is present in the field during the two shifts of powering tests: it is composed of one AB/OP operator and one member of the Hardware Commissioning Coordination
6. The magnets are left floating in temperature after the commissioning of a sector.
7. The RF system is commissioned during the six months preceding the commissioning with beam in the machine as described in LHC-A-HCP-0001 [9]. Only in this case all the resources required for cryogenics (operation crews and instrumentation commissioning) are available.
8. The PS complex and SPS run in 2006.

The resulting schedule for this scenario is given in Appendix I: it shows the sequence of tests and the parallelism which was assumed.

3. THE IMPACT OF THE DIFFERENT PHASES

For all Groups concerned by the Commissioning of the Superconducting Electrical Circuits, the same pattern is encountered; namely the installation, the individual systems tests and finally the commissioning of the circuits. While the first two concern the Groups individually, the latter involve many Groups together which find themselves in a position of *service provider* and *service requester* simultaneously. These two modes strongly affect the type, and number of the resources deployed.

4. THE DIFFERENT CATEGORIES OF PERSONNEL

Four categories of personnel will be involved in the individual systems tests and the commissioning activities. They are:

	Category	**Abbreviation**
1	CERN staff	S
2	Collaborations with national institutes	NI
3	Industrial Support either Work Package with responsibility or task oriented	IS
4	Field Support Units	FSU

In category 1 we include both the staff on indefinite contracts and the staff which will be hired on limited duration contracts for LHC commissioning.

5. PRESENCE

The tables below also include a column defining whether the personnel is deployed in *Field* or is *On call*. The On-call service can take the following three different forms:

On-call	during the period specified
On-call for 8 hours per 24 hours	this refers to staff available during an 8 hour working day in support of a team deployed in the field during two shifts; continued presence of staff in the field will be guaranteed in case of emergency through flexible hours; this however can not be extended without limit.
On-call for 24 hours	this refers to a 24 hour piquet service which can either support a team present in the field for two shifts or complement it when needed during the 8 hour unmanned operation of the equipment

6. THE ACTIVITIES

The sections below describe the activities, the personnel involved, the time it takes and the parallelism when applicable. Some of the activities below take place during the Individual System Tests (ISTs) of a system, others during the Powering Tests. In these two phases the working hours and the staff deployed are different; during the powering tests all the parties involved are *present in the field* or provide an *on-call service* during two shifts per day. During this phase personnel involved in the commissioning of the electrical circuits is deployed on two fronts on each sector.

After the description of each activity, a table gives the details of each team involved. In this table, the column called **Needed** contains the number of people needed taking into account the shifts and the two fronts per sector.

6.1 OPERATION OF CRYOGENICS DURING THE LEAK AND PRESSURE TESTS

After the temporary closure of the interconnects the leak and pressure test of the helium vessel and leak test of the vacuum vessel of the cryogenic subsectors of each sector will take place.

This activity will involve mainly the Vacuum Group, however they will have to be assisted by the operators of the cryogenic system in order to pressurize and evacuate the lines for the needs of the tests.

The test is programmed for two weeks per sector and will involve one technician (S) and two operators (IS). Since personnel for this activity will be drawn from the COCD team (Cryogenic Operation during Initial Cool Down see below), this will either have an impact on the cool down times, or the leak and pressure tests will have to be carried-out when the COCD team is idle.

Team Name	COLPT – Cryogenic operation during leak and pressure tests				
Range of Action	One sector				
Presence	One shift, five days a week				
Composition				**Needed**	**Missing**
1	Technician	Field	Staff	1	0
2	Operators	Field	IS	2	0

6.2 CRYOGENIC INSTRUMENTATION INDIVIDUAL SYSTEM TESTS AT WARM

After the positioning and connection of the electronic crates to the local cabling, the commissioning of the cryogenic instrumentation and process control equipment takes place in three phases which are staggered. This activity takes 30 weeks for the first two sectors (NB at the same time) and 20 weeks for the subsequent sectors. The durations given below are 50% higher for the first pair of sectors. The three phases are:

1. Crate stand-alone start-up (CIWSU): these consist in the validation of the instrumentation connected to the crates. This phase requires 8 (12 for the first sectors) weeks, 4 technical engineers and 4 technicians.
2. Connection of the custom electronics to the fieldbus (CIWCE): setting the WFIP network, verification that all the instruments and that process data are available at the gateways. This phase requires 8 (12 for the first sectors) weeks, 2 engineers, 1 technician and AB-CO support on call.
3. Control system commissioning (CIWCS): check of (a) channel coherence (from the field to the SCADA database), (b) programs, (c) process logic, (d) alarms, interlocks, etc;

   During this last phase the Profibus network, which had already been checked during the QRL cold tests, will be restarted. This phase requires 14 (21 for the first sectors) weeks, 4 engineers, 1 Unicos engineer and 4 technicians.

During the cryogenic instrumentation IST at warm, the Cryogenic Operation team supports the Cryogenic Instrumentation team.

The costs for the missing FSU are given for the commissioning of 2 sectors : nominal and two first sectors in brackets.

Team Name	CIWSU - Crate stand-alone start-up				
Range of Action	Two adjacent sectors around an even point				
Presence	One shift, five days a week				
Composition				**Needed**	**Missing**
4	Technical Engineer	Field	Staff	4	2
4	Technician	Field	FSU	4	70 (105) kCHF

Team Name	CIWCE - Connection of the custom electronics to the fieldbus				
Range of Action	Two adjacent sectors around an even point				
Presence	One shift, five days a week				
Composition				**Needed**	**Missing**
2	Engineer	Field	Staff	2	0
1	Technician	Field	FSU	1	18 (27) kCHF

It is worthwhile mentioning that one of the two available engineers foreseen for this activity is presently on a Fellow contract and can therefore disappear anytime.

Team Name	CIWCS - Cryo control system commissioning			
Range of Action	Two adjacent sectors around an even point			
Presence	One shift, five days a week			
Composition			**Needed**	**Missing**
4 Technical Engineer	Field	Staff	4	4
4 Technician	Field	FSU	4	122 (183) kCHF
1 Unicos Engineer	Control room	IS	1	75 (113) kCHF

A support team is available on call to assist the staff in the field during

- the commissioning of the instrumentation and the control system,
- the cool down and the fine tuning of the process control system (see Section 5.3)
- the optimisation of the control system (see Section 5.4).

Team Name	CIWSP - Support team			
Range of Action	Two adjacent sectors around an even point			
Presence	One shift, five days a week			
Composition			**Needed**	**Missing**
1 Engineer	On call	Staff	1	0
1 Database Engineer	On call	Staff	1	1

The Database Engineer is trained and is presently on a Fellow contract until September 2005.

6.3 COOL DOWN AND FINE TUNING OF THE CRYOGENIC SYSTEM

The cool down of the magnets of the two sectors around an even point is carried-out by a cryogenic operation team composed of one engineer (S), two technicians (S) and four operators (IS) during normal working hours.

The cryogenic instrumentation IST at cold is performed in parallel with cool down and also at nominal operation conditions. It consists in the follow-up of instrumentation behaviour during cool down, validation of instrumentation at nominal conditions, and check and tuning of the control logic during each phase of operation.

This activity takes 10 weeks for the first two sectors and 8 weeks for the subsequent sectors.

The cryogenic instrumentation team is composed of two engineers (S), two technical engineers (S), two technicians (S), and one Unicos engineer (IS). The team assists the operation team for the validation and tuning of the cryogenic instrumentation and controls.

The costs for the missing IS and FSU are given for the commissioning of 2 sectors : nominal and two first sectors in brackets.

Team Name	COCD - Cryogenic Operation during initial cool down			
Range of Action	Two adjacent sectors around an even point			
Presence	One shift, five days a week On-call 24h/day and 7days/week			
Composition			**Needed**	**Missing**
1 Engineer	On-call	Staff	1	0 (1)
2 Technician	Field	Staff	2	0 (2)
2 Operator	Field	IS	2	0
1 Operator	On-call	IS	2	0 (80-100)kCHF

Depending on the parallelism of other cryogenic individual system tests (QRL, cryoplants …) imposed by revisions of the installation schedule, the required engineers, technicians and operators could be all missing as shown by the figures in brackets.

Team Name		CICCT - Cryogenic Instrumentation IST during cool down			
Range of Action		Two adjacent sectors around an even point			
Presence		One shift, five days a week			
Composition				**Needed**	**Missing**
2	Engineer	Field	Staff	2	2
2	Technical Engineer	Field	Staff	2	2
2	Technician	Field	FSU	2	40-50 kCHF
1	Unicos Engineer	Control room	IS	1	45-56 kCHF

One of the two engineers needed for this activity is presently on a Project Associate contract and can therefore disappear anytime; he is therefore considered as missing.

6.4 OPERATION OF CRYOGENICS AND OPTIMIZATION OF THE CRYOGENIC SYSTEM DURING POWERING TESTS

The cryogenic operation team maintains nominal operating conditions and recovery during the powering tests. These will take place in two shifts five days a week. During each shift one technician (S) and two operators (IS) will be deployed. They will be supervised by an engineer (S) who will be on call during normal working hours. This team is composed of the members of the team involved in the cool down (COCD) with the addition of the manpower required for supporting the powering tests in two shifts.

During the powering tests, the Cryogenic Instrumentation team supports the Operation Team with one Engineer (S) and one Technician (S); it is active on the two sectors, for the optimization of the control system (e.g. quench recovery). The team members except the FSU, are already counted in the team for Cryogenic Instrumentation IST during cool down.

The activity takes between 11 and 13 weeks depending on the number electrical of circuits on the sector.

The costs for the missing IS and FSU are given for the commissioning of 2 sectors (11–13 weeks)

Team Name		COPT - Cryogenic Operation during Powering			
Range of Action		Two adjacent sectors around an even point			
Presence		Two shifts, five days a week; On-call 24h/day and 7days/week			
Composition				**Needed**	**Missing**
1	Engineer	On call	Staff	1	0 (1)
2	Technician	Field	Staff	4	0 (4)
2	Operators	Field	IS	4	105-125 kCHF
1	Operators	On call	IS	4	105-125 kCHF

Depending on the parallelism of other cryogenic individual system tests (QRL, cryoplants …) imposed by revisions of the installation schedule, the required engineers, technicians and operators could be all missing as shown by the figures in brackets.

Team Name	CICOP - Optimization of the process control system at nominal conditions				
Range of Action	Two adjacent sectors around an even point				
Presence	Two shifts, five days a week				
Composition				**Needed**	**Missing**
1	Engineer	Field	Staff	1	0
1	Technician	Field	FSU	1	25-30 kCHF

6.5 ELECTRICAL QUALITY ASSURANCE

There will be one team present in the field working one shift/day. It is composed of one expert and one technician. After the installation of the equipment is finished the Electrical Quality Assurance at warm will take two weeks. During the cool down equipment will be installed to monitor the Electrical Quality during the cool down. The Electrical Quality Assurance at cold will take 3 weeks. For both the warm and cold tests the same team will carry-out the tests provided they do not fall at the same time. A time lag of three weeks between the commissioning of the two sectors was introduced in the schedule given in Appendix 1 in order to ensure that this team can be deployed on both sectors.
As the team is in principle only 5*8=40 weeks in the tunnel, it seems prudent to rely on the installation teams for illness and holiday backup.

Team Name	ELQA - Electrical Quality Assurance				
Range of Action	One sector				
Presence	One shift, five days a week				
Composition				**Needed**	**Missing**
1	Expert	Field	Staff	1	0
1	Technician	Field	Staff	1	0

6.6 QUENCH PROTECTION INDIVIDUAL SYSTEM TESTS

There will be one team present in the field working one shift/day. It is composed of one expert, one engineer and one technician. The QPS ISTs at warm include the fieldbus and detector tests and the dry tests of the extraction systems. The connection of the magnets and heaters will also take place during this phase. It is expected to take 2 days per sector. This will be followed by a final check of the system.

After the cool down the QPS IST will be carried-out and they will last for 4 weeks. A time lag of three weeks between the commissioning of the two sectors was introduced in the schedule given in Appendix 1 in order to ensure that this team can be deployed on both sectors.

As the team is in principle only 5*8=40 weeks in the tunnel, it seems prudent to rely on the QPS powering teams for illness and holiday backup.

Team Name	QPIST - Quench Protection ISTs				
Range of Action	One sector				
Presence	One shift, five days a week				
Composition				**Needed**	**Missing**
1	Expert	Field	Staff	1	0
2	Technician	Field	Staff	2	2
2	Operator/Technician	Field	FSU	2	0

6.7 QUENCH PROTECTION DURING POWERING TESTS

There will be two teams present in the field working two shifts per day. Each team is composed of half an expert, one engineer and one technician.

The two teams carry-out the heater tests, energy extraction tests with current and support the powering teams in parallel in two sectors. As these teams will need all the time available, one back up team will be needed for holidays, illness etc. One backup team will also be sufficient when the commissioning of 4 sectors at a time will eventually be necessary.

Team Name		QPPT - Quench Protection Powering			
Range of Action		Two adjacent sectors around an even point			
Presence		Two shifts, five days a week			
Composition				**Needed**	**Missing**
0.5	Expert	Field	Staff	3	0
1	Engineer	Field	Staff, NI	5	5
1	Technician	Field	Staff, NI	5	5

The calculation above also includes the backup team for the powering tests.

6.8 MACHINE INTERLOCK SYSTEM INDIVIDUAL SYSTEM TESTS

Powering interlock system for superconducting magnets: During the individual system tests there will be one shift per day with one expert (CERN staff, member of the interlock team in AB-CO) and one senior technician. On the average, the tests will take about 40 days for two sectors and will include the installation and interface tests of the powering interlock controller in the LHC underground areas.

Team Name		MIIST - Machine interlocks individual system tests			
Range of Action		Two adjacent sectors around an even point			
Presence		One shift per day, five days a week			
Composition				**Needed**	**Missing**
1	Expert	Field	Staff	1	0
1	Senior technician	Field	FSU	1	50 kCHF

6.9 MACHINE INTERLOCK SYSTEM SUPPORT FOR PC ON SHORT CIRCUITS

The machine interlock team will contribute to the commissioning of some of the electrical circuits with sc magnets (main bending and quadrupole circuits), since the 13kA energy extraction system must be operational. The signal from the energy extraction system is transmitted via the powering interlocks to the power converters.

During these tests there will be one shift per day with one expert (CERN staff, member of the interlock team in AB-CO) and one senior technician. On the average, the tests will take about 4 days for the two sectors.

Team Name		MI-PCIST - Machine interlocks during PC short circuit tests			
Range of Action		Two adjacent sectors around an even point			
Presence		One shift per day, five days a week			
Composition				**Needed**	**Missing**
1	Expert	Field	Staff	1	0
1	Senior Technician	Field	Staff	1	0

6.10 MACHINE INTERLOCK SYSTEM DURING POWERING TESTS

During this phase, the machine interlock team will commission the powering interlocks for the superconducting magnets and provide support during the commissioning of the electrical circuits up to nominal current.

During the powering tests there will be two shifts per day. During each shift, there will be two interlock teams. Each team consists of two people: one expert (CERN staff, member of the interlock team in AB-CO) and one senior technician.

In addition, there will be one expert and one senior technician on call to support the powering procedures up to nominal current once the interlock system is fully commissioned. They will spend about 30% to 50% of their time on this duty.

The senior technicians require some knowledge of the interlock system and should be trained some months in advance.

Team Name MIPT - Machine interlocks during powering tests
Range of Action Two adjacent sectors around an even point
Presence Two shifts per day, five days a week

Composition				**Needed**	**Missing**
1	Expert	Field	Staff	4	0
1	Expert	On call	Staff	0.6	0
1	Senior Technician	Field	Staff, NI	4	4
1	Senior Technician	On call	Staff, NI	1	1

6.11 POWER CONVERTER INDIVIDUAL SYSTEM TESTS

After the installation of the equipment in the UAs, RRs and the tunnel, a 3 week campaign will be carried out by the teams of TS-EL and TS-CV: they will connect the AC, DC and water. This will be followed by the short circuit test which is the PCIST proper. There will be one team present in the field working one shift per day and five days a week. It is composed of half of one engineer (S), one senior technician (S), two engineers (FSU) and three technicians (FSU) for two adjacent sectors. Support from specialists (S) having performed the reception tests will be available.

Team Name PCIST - Power Converter ISTs
Range of Action Two adjacent sectors around an even point
Presence One shift, five days a week

Composition				**Needed**	**Missing**
0.5	Engineer	Field	Staff	0.5	0
2	Engineer	Field	FSU	2	0
1	Senior Technician	Field	Staff	1	0
3	Technician	Field	FSU	3	0

6.12 POWER CONVERTERS DURING POWERING TESTS

Two senior engineers (one engineer in charge per week) will supervise and organize these tests in close collaboration with the Coordination of Hardware Commissioning.

There will be one team present in the field working two shifts per day (6h-22h) and five days a week. The team will be in charge of the powering tests of both sectors around an even point. The team is composed of two technicians (FSU) present in the field during each shift: they are supported by two engineers (S+FSU) and one technician (S) for these tests and available on request but not necessarily present in the field all the time. They are in charge for one week and their presence in the field is 8h per day.

Support from specialists (S) will be available: 6 FTE engineers and 10 FTE technicians.

Team Name PCPT - Power Converter Powering
Range of Action Two adjacent sectors around an even point
Presence Two shifts, five days a week
Composition

				Needed	Missing
1	Supervision engineer	8h per day	Staff	1	0
1	Engineer in charge	8h per day	Staff	1	0
1	Engineer	8h per day	FSU	1	0
1	Technician	8h per day	Staff	1	0
2	Technician	Field	FSU	5	400 kCHF/year
7	Specialist engineer	8h per day	Staff	7	1.5
9	Specialist technician	8h per day	Staff	9	2.5

The evaluation of the missing staff is based on the AB Staff plan made in October 2004 with the assumptions of the running of the PS complex and SPS in 2006 during the powering tests (Basic Assumption 8).

6.13 COORDINATION OF HARDWARE COMMISSIONING

The hardware commissioning team will be present in the field control rooms, will intervene in case of events of any nature impairing on the smooth progress of the commissioning and will be involved in administrative work related to the handling and the management of test data and its interpretation.

Team Name HCC - Hardware Commissioning Coordination
Range of Action Two adjacent sectors around an even point
Presence Two shifts, five days a week
Composition

				Needed	Missing
2	Engineer	Field	Staff	6	4
2	Technician	Field	Staff	6	6

6.14 CONTROL SYSTEM SUPPORT

A team from the AB-CO Group will provide field support, with additional on call support, for the entire infrastructure it supplies. Because of the wide range of systems being considered different expertise is required to provide these services for both the industrial control systems and the accelerator control systems.

The field support will be a technician present at the even point being commissioned with on-call backup. This level of service is similar to the one provided to accelerator operations. In order to ensure this it is necessary to decouple the services given to the CCC and to the FCR for hardware commissioning. Therefore additional personnel is required during the hardware commissioning periods. It is expected that the interventions take place within one hour from the call.

Team Name COFL – First Line Support
Range of Action Two adjacent sectors around an even point
Presence Two shifts, five days a week
Composition

				Needed	Missing
1	Engineer	On call 8 hours per 24 hours	Staff	1	0
1	Technician	Field	Staff	3	1

An early feature of operating a complex system such as the LHC hardware will be a surge in demand for evolution and improvement of the control software. Again considering the range of expertise required, the parallel developments for beam commissioning and comparing with the LEP experience 2 engineers are needed during the hardware commissioning period.

Team Name COSS – Controls Software Support
Range of Action Two adjacent sectors around an even point
Presence One shift per day, five days a week
Composition

				Needed	Missing
1	Software Engineer (Industrial Control)	Field	Staff/IS	1	1 or 200kCHF/year
1	Software Engineer (Accelerator Systems)	Field	Staff/NI	1	1

6.15 OPERATION

A team from the AB-OP Group will support the hardware commissioning activities by manning the field control room or the console devoted to Hardware Commissioning in the CCC with one operator during two shifts throughout the commissioning of the LHC without beam.

The duty of the operator and the technician associated to him/her from the Hardware Commissioning Coordination team is to give assistance in terms of status information, liaison with other teams, taking over the monitoring of automatic procedures, etc.

Team Name ABOP - Operation
Range of Action Two adjacent sectors around an even point
Presence Two shifts, five days a week
Composition

				Needed	Missing
1	Operator	Field	Staff	4	0
0.5	Engineer	Field	Staff	1	0

The staff required to support the hardware commissioning is in the AB-OP Group Staff Plan of October 2004 with the assumption of the running of the PS complex and SPS in 2006 but not more than two sectors are commissioned in parallel (Basic Assumption 1 and 8).

7. SUMMARY

During the exercise, the Groups concerned have carefully looked at the occupation profile of the resources requested in order to ensure an optimal occupation of the resources. Obviously these profiles are not flat, they present peaks and dips which will be smoothed when the whole picture of the complete commissioning becomes known.

The figures given for each team have been integrated in one single table given in Appendix II. They indicate that the **personnel involved in the individual system tests and the hardware commissioning has been evaluated to 143 of which 46 are missing**. **An additional budget for IS and FSU of 1.335 MCHF is also needed.**

	Missing	Possible Source
Cryogenic Instrumentation / Process Control		
Technical Engineer	8	Staff, NI
Engineer	2	Staff, NI
Database Expert	1	Staff
Quench Protection		
Technician	7	Staff, NI
Engineer	5	Staff, NI
Machine Interlocks		
Technician	5	Staff, NI
Electrical Engineering (Power Converters)		
Technician	3	Staff
Engineer	2	Staff
Commissioning Coordination		
Technician	6	Staff
Engineer	4	Staff, NI
Controls		
Technician	1	Staff
Engineer	2	Staff, NI, IS

8. CONCLUSIONS

We would like to emphasize that the figures above are strongly coupled to the scenario given in Appendix I and to the basic assumptions given in Chapter 2: a modification of any of these (e.g. increased parallelism, more than two sectors in parallel, two sectors not situated around an even point, etc.) will impact both on the personnel needed and the personnel missing. The impact has in some cases been included in the tables.

Where the missing personnel is identified as staff, it is requested that they are hired a year in advance of the start of the test and commissioning activity for obvious needs of training.

9. REFERENCES

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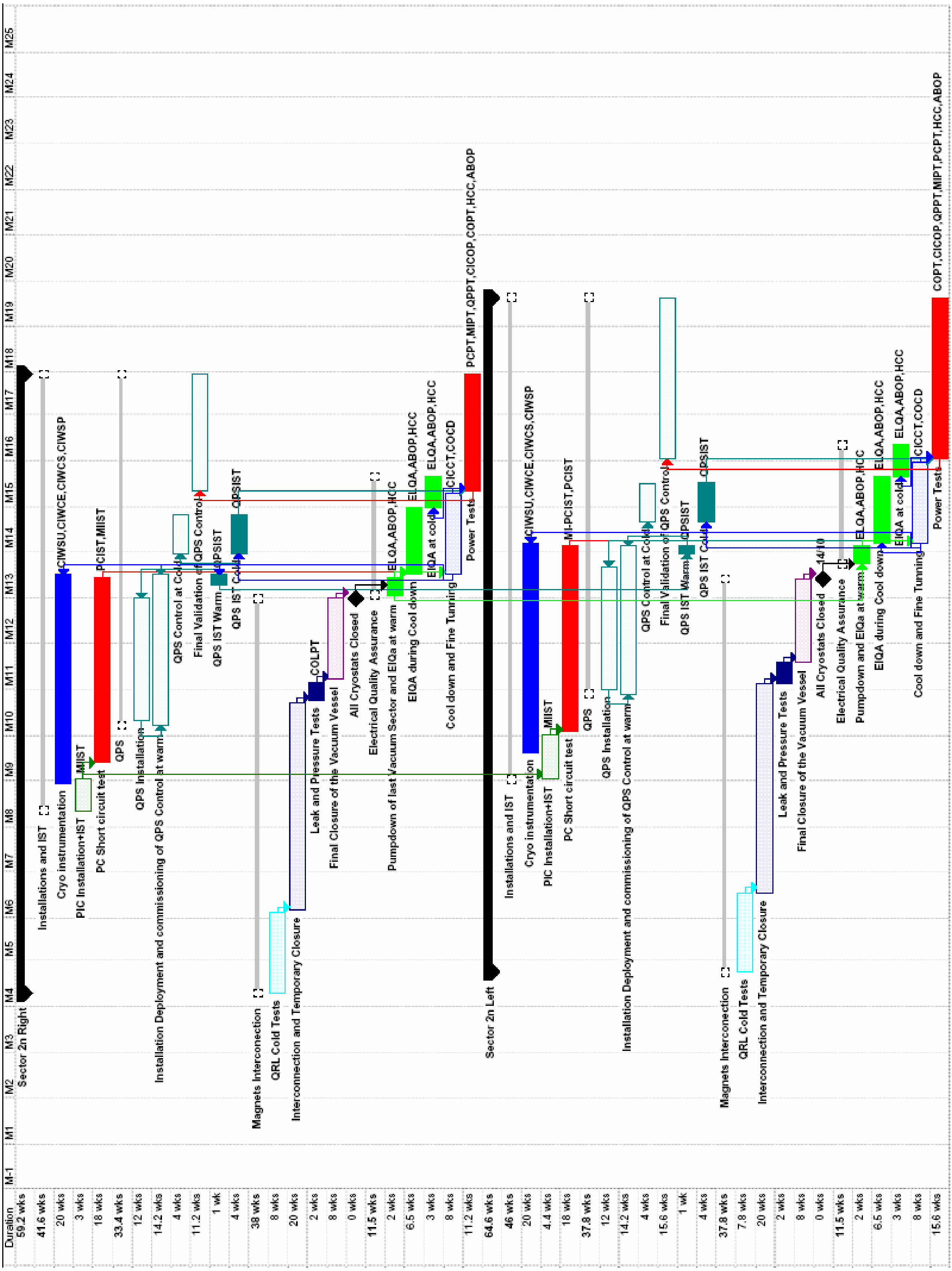
[9] O. Brunner et al., The Commissioning of the RF System in Point 4, LHC-A-HCP-0001 - released

APPENDIX I. : COMMISSIONING SCHEDULE FOR TWO SECTORS IN PARALLEL



APPENDIX II. : SUMMARY TABLE

Team	Number		Presence	Category	Needed Staff	Missing Staff	Missing Staff if increased parallelism	Cost of FSU or IS [kCHF]
COLPT	1	Technician	Field	Staff	1	0		
COLPT	2	Operators	Field	IS	2	0		
CIWSU	4	Technical Engineer	Field	Staff	4	2		
CIWSU	4	Technician	Field	FSU	4			70
CIWCE	2	Engineer	Field	Staff	2	0		
CIWCE	1	Technician	Field	FSU	1			18
CIWCS	4	Technical Engineer	Field	Staff	4	4		
CIWCS	4	Technician	Field	FSU	4			122
CIWCS	1	Unicos Engineer	Control room	IS	1			75
CIWSP	1	Engineer	On-call	Staff	1	0		
CIWSP	1	Database Engineer	On-call	Staff	1	1		
COCD	1	Engineer	On-call	Staff	1	0	1	
COCD	2	Technician	Field	Staff	2	0	2	
COCD	2	Operator	Field	IS	2	0		
COCD	1	Operator	On-call	IS	2	0		80
CICCT	2	Engineer	Field	Staff	2	2		
CICCT	2	Technical Engineer	Field	Staff	2	2		
CICCT	2	Technician	Field	FSU	2			40
CICCT	1	Unicos Expert	Field	IS	1			45
COPT	1	Engineer	On call	Staff	1	0	1	
COPT	2	Technician	Field	Staff	4	0	4	
COPT	2	Operators	Field	IS	4			105
COPT	1	Operators	On call	IS	4			105
CICOP	1	Engineer	Field	Staff	1	0		
CICOP	1	Technician	Field	FSU	1			25
ELQA	1	Expert	Field	Staff	1	0		
ELQA	1	Technician	Field	Staff	1	0		
QPIST	1	Expert	Field	Staff	1	0		
QPIST	2	Technician	Field	Staff	2	2		
QPIST	2	Operator/Technician	Field	FSU	2	0		
QPPT	0.5	Expert	Field	Staff	3	0		
QPPT	1	Engineer	Field	Staff, NI	5	5		
QPPT	1	Technician	Field	Staff, NI	5	5		

Team	Number		Presence	Category	Needed Staff	Missing Staff	Missing Staff if increased parallelism	Missing FSU or IS [kCHF] [kCHF]
MIIST	1	Expert	Field	Staff	1	0		
MIIST	1	Senior technician	Field	FSU	1			50
MI-PCIST	1	Expert	Field	Staff	1	0		
MI-PCIST	1	Senior Technician	Field	Staff	1	0		
MIPT	1	Expert	Field	Staff	4	0		
MIPT	1	Expert	On call	Staff	0.6	0		
MIPT	1	Senior Technician	Field	Staff, NI	4	4		
MIPT	1	Senior Technician	On call	Staff, NI	1	1		
PCIST	0.5	Engineer	Field	Staff	0.5	0		
PCIST	2	Engineer	Field	FSU	2	0		
PCIST	1	Senior Technician	Field	Staff	1	0		
PCIST	3	Technician	Field	FSU	3	0		
PCPT	1	Supervision engineer	8h per day	Staff	1	0		
PCPT	1	Engineer in charge	8h per day	Staff	1	0		
PCPT	1	Engineer	8h per day	FSU	1	0		
PCPT	1	Technician	8h per day	Staff	1	0		
PCPT	2	Technician	Field	FSU	5			400
PCPT	7	Specialist engineer	8h per day	Staff	7	1.5		
PCPT	9	Specialist technician	8h per day	Staff	9	2.5		
HCC	2	Engineer	Field	Staff	6	4		
HCC	2	Technician	Field	Staff	6	6		
COFL	1	Engineer	on call 8h	Staff	1	0		
COFL	1	Technician	Field	Staff	3	1		200
COSS	1	Software Engineer (Industrial Control)	Field	Staff/IS	1	1		
COSS	1	Software Engineer (Accelerator Systems)	Field	Staff/NI	1	1		
ABOP	1	Operator	Field	Staff	4	0		
ABOP	0.5	Engineer	Field	Staff	1	0		
					143	45		1335